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Mathematical analogical reasoning ability based on the thinking style of junior high school students on flat surface of solid figures

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Abstract

Analogical reasoning ability teaches students how to translate abstract concepts into a concrete ones. Students can receive and process information from this knowledge according to their thinking style. Therefore, this study aims to determine students' mathematical analogical reasoning ability at SMP Negeri 1 Sungai Raya based on their thinking style. The research method used in this research is quantitative descriptive analysis, with data analysis assisted by Anates V4 software. The subjects in this study were 29 class IX A students at SMP Negeri 1 Sungai Raya. Data collection techniques used in this study include measurement and direct and indirect communication. The instruments used were mathematical analogical reasoning tests, thinking style tests, and interview guidelines. The results showed that students who had a concrete sequential thinking style obtained an average value of mathematical analogical reasoning ability of 46.25 in the good category, while the average value of students with abstract sequential mathematical analogical reasoning ability was 31.50, concrete random 27.83, and random abstract 32.07 in the medium category. The findings mean that the classroom learning pattern needs to be maintained while improving students' mathematical analogical reasoning abilities. In addition, students are expected to maximize their potential according to the character of their thinking style.

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INTRODUCTION

As a universal science, mathematics is important in advancing human thinking power. The science of mathematics in education helps students cultivate the ability to think, reason, and use logic, which will shape their understanding of learning (Dewi & Alam, 2020). In learning mathematics, students will be directed to understand concepts well (Siagan et al., 2019) because good learning outcomes start with students who can solve problems by applying mathematical concepts (Irawan & Surya, 2017). The mathematical concept is an abstract concept that is quite difficult for students to understand (Simamora & Saragih, 2019; Veith & Bitzenbauer, 2022), so a mathematical ability is needed to help students be able to understand mathematical concepts.

Permendikbud no 21 of 2016 states that one of the learning competencies that must be achieved at the junior high school level is demonstrating reasoning abilities, both in abstract and concrete domains (Agastya et al., 2022; Andiani et al., 2021). Meanwhile, one of the 2013 curriculum's learning objectives is to use reasoning on properties, manipulate mathematics both in simplification and to analyze the components that exist in problem-solving in the context of mathematics and outside of mathematics (Mariyam et al., 2019; Santi et al., 2019). Reasoning is one of the abilities that students must possess. However, Indonesian students' reasoning is currently low (Sandy et al., 2019; Toba & Noor, 2019). The Trend in International Mathematics and Science Study (TIMSS) survey in 2015 stated that students in Indonesia are generally not good at cognitive aspects such as knowledge, application, and reasoning (Kartianom & Retnawati, 2018; Mejía-Rodríguez et al., 2021). The same thing is shown through the results of the 2018 PISA test, which

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placed Indonesia at 74 out of 79 in the mathematics aspect (Pramana et al., 2021; Rahmi et al., 2021; Siswandari et al., 2021). The mathematics learning system in Indonesia, which focuses on obtaining learning outcomes without paying attention to students' abilities, can contribute to weak reasoning abilities.

Reasoning abilities can help students connect systematic facts or data, explore ideas, and identify solutions to produce conclusions from relevant knowledge in a mathematical context (Abidin et al., 2020). Students' reasoning abilities help them understand what they are doing, not just remembering facts, rules, or procedures but also using their reasoning abilities to make predictions based on experience to understand related concepts (Hawthorne et al., 2022; Qomariyah & Darmayanti, 2023). An analogy is one of the many methods of reasoning (Agusantia & Juandi, 2022; Maghfiroh & Rosyidi, 2021).

Analogical reasoning ability is a problem-solving strategy that begins with similarities between previously solved problems and current problems (Safitri et al., 2021). Analogical reasoning in mathematics is used to connect students' existing knowledge with questions that have the same concept or procedure that provides students with the knowledge to describe abstract concepts into concrete (Wardhani et al., 2016) so that students can associate material that has similar concepts and processes in solving problems. Students with low analogical reasoning abilities can only use basic formulas to solve problems and cannot develop these formulas for solving other similar problems (Nurma & Rahaju, 2021). The flat surface of solid figures is one of the mathematics topics taught in junior high school. This material uses analogical reasoning to help students understand the concepts of surface area and volume of flat shapes. With their analogical reasoning abilities, it is hoped that students can more easily determine the appropriate action to solve problems related to the concept of flat shapes.

In an analogy, part of the reasoning cannot be separated from the thought process. Reasoning and thinking are two very important abilities in learning mathematics (Ayal et al., 2016). There are two activities in thinking, namely, receiving and processing information (Rudianto et al., 2022). The thinking style is the mindset that distinguishes a person's way of receiving, processing, and utilizing the information obtained (Belousova, 2014). The thinking style of students is influenced by their habits when receiving learning related to the learning environment (Hidayat et al., 2019; Utami et al., 2020). Students' information-gathering styles fall into four categories: concrete sequential, abstract sequential, concrete random, and abstract random (Halim et al., 2021; Jegatha et al., 2014). This grouping of thinking styles will assist the teacher in providing feedback on student errors when solving questions. In learning mathematics, each student has a different style of thinking according to how they learn, which will help students use the information obtained in solving problems. A variety of thinking styles provides space for students to understand learning material according to their learning style so that the material conveyed by the teacher can be understood properly.

Several studies that have been conducted state that mathematical analogical abilities have a good influence on mathematical abilities (Nurma & Rahaju, 2021), problem-solving (Safitri et al., 2021), *self-efficacy* (Agustiana et al., 2019), and learning motivation (Wulandari et al., 2021). Likewise, regarding the style of thinking in learning, students who use their thinking style well in processing information will also have good learning outcomes (Susilawati & Saragih, 2014). Based on several existing studies that have shown a positive effect, no research has been found regarding analogical reasoning abilities based on the thinking styles of junior high school students, especially on the flat surface material. Therefore, this study aims to obtain an overview of junior high school students' mathematical analogical reasoning abilities with different thinking styles on flat surface objects.

METHOD

The method used in this research is quantitative descriptive analysis. The phenomenon described in this study is students' mathematical analogical reasoning as observed through their thinking style. The subjects in this study were the ninth-grade students at one of West Kalimantan's junior high schools, totaling 29 students. Data collection techniques used in this study include measurement and direct and indirect communication. The instruments used were interviews,

questionnaires, and essays with validated instruments. Data analysis was performed with the help of Anates V4 software.

The steps in the implementation stage of the research consist of: (1) giving a mathematical analogical reasoning test; (2) giving a thinking style test; (3) providing scores and analyzing the results of the two tests; (4) selecting eight students to be interviewed; (5) conducting interviews; and (6) analyzing interview data. In the final stage, the researcher compiled a report based on the data obtained.

The results of the thinking style test were scored according to the scoring guidelines and then grouped into four categories, namely abstract random (AR), concrete random (CR), abstract sequential (AS), and concrete sequential (CS) (Hadiastuti & Soedjoko, 2019). The dominant score that students have determines their type of thinking style. There are four steps in solving analogical reasoning questions: *encoding, inferring, mapping,* and *applying* (Pradita et al., 2021). From these stages, the mathematical analogical reasoning test results were scored according to the scoring guidelines, and then the average and standard deviation were calculated. Furthermore, the data is grouped based on the following criteria:

Table 1. Students' Mathematical analogical Reasoning Criteria

$\underline{x}$	SD	The Category of Mathematical analogical Reasoning		
		Tall $(x \geq \underline{x} + SD)$	Medium $(\underline{x} - SD \leq x < \underline{x} + SD)$	Low $(x < \underline{x} - SD)$
33	9,9	$x \geq 42{,}9$	$23{,}1 \leq x < 42{,}9$	$x < 23{,}1$

Description:
$\underline{x}$ = average
SD = standard deviation
x = students' mathematical analogical reasoning test scores

According to the criteria listed in table 1, students' analogical reasoning is grouped with the following conditions: (1) students with a score of 42,9 or more have high mathematical analogical reasoning abilities; (2) students with a score of more than or equal to 23,1 and less than 42,9 have medium mathematical analogical reasoning abilities; and (3) students with a score of less than 23,1 have low mathematical analogical reasoning abilities. Meanwhile, the interview data were transcribed into written form and reduced without changing the meaning intended by the students. Finally, the researcher concludes the results of the data analysis.

RESULTS AND DISCUSSION

The thinking style test was given to 29 ninth-grade students at a West Kalimantan junior high school. The results are presented in Table 2:

Table 2. Student Thinking Style Test Results

Types of Thinking Styles	Student	Percentage
Concrete Sequential	4	14%
Abstract Sequential	4	14%
Concrete Random	5	17%
Abstract Random	16	55%
Total	29	100%

Based on Table 2, it can be seen that the type of thinking style most students have is abstract random, which is expressed by 55% (16 people). In addition, 17% (5 people) have a concrete random thinking style, 14% (4 people) have an abstract sequential thinking style, and 14% (4 people) have a concrete sequential thinking style. Furthermore, the data on students' mathematical analogical reasoning test results show the following results:

Table 3. Results of the Mathematical analogical Reasoning Test

Value Intervals	Students	Percentage	Analogical Reasoning category
$x \geq 42{,}9$	8	28 %	Tall
$23{,}1 \leq x < 42{,}9$	16	55 %	Medium
$x < 23{,}1$	5	17 %	Low
Total	29	100 %	

Table 3 shows that most students in class IX A have mathematical analogical reasoning abilities in the medium category, namely 16 people (55%). In comparison, eight people (28%) have mathematical analogical reasoning abilities in the high category and five (17%) in the low category. Overall, an average score of 33.1 was obtained, so students' mathematical analogical reasoning was classified in the medium category. The thinking style data and analogical reasoning abilities that have been obtained are then paired, and the results are presented in the following figure:

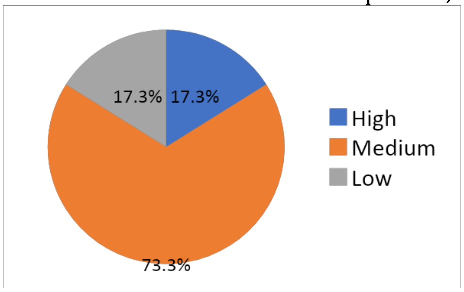

Figure 1. Reasoning Ability of Mathematical analogical in Abstract Random Thinking Style

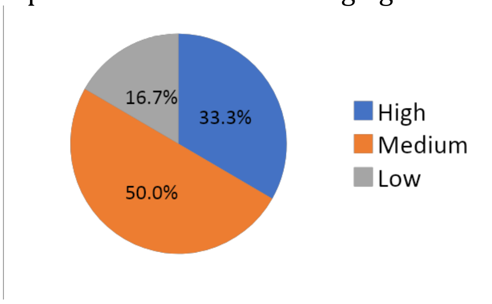

Figure 2. Reasoning Ability of Mathematical Analogies in Concrete Random Thinking Styles

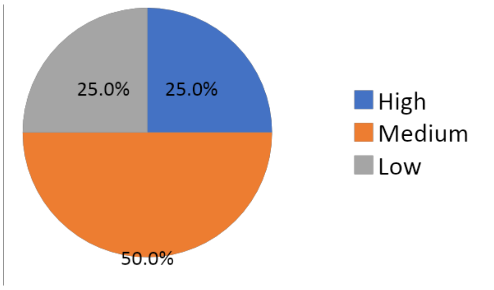

Figure 3. Reasoning Ability of Mathematical analogical in Abstract Sequential Thinking Style

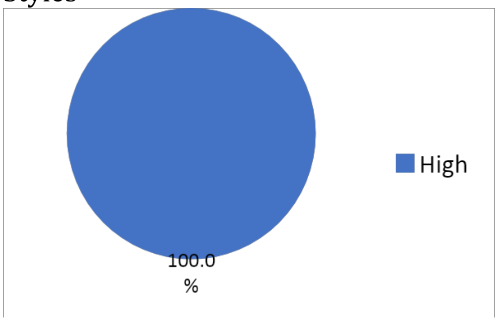

Figure 4. Mathematical analogical Reasoning Ability in Concrete Sequential Thinking Style

After pairing the data, it was found that students with AR, CR, and AS thinking styles had varied mathematical analogical reasoning abilities. Students with the CS thinking style have high mathematical analogical reasoning abilities.

Students with a random abstract thinking style (AR) have an average test score of 32.07, which is included in the moderate mathematical analogical reasoning ability category. In general, at the *encoding*, students' ability to write down information from the problem's source and the problem's target is good. At the *infer*ence, the student's ability to perform calculations to determine a low relationship to the source of the problem or to conclude a low relationship from the calculation results is still not good. At the *mapping*, students' ability to identify the relationship between the source of the problem and the target problem is quite good. At the stage of *applying*, the ability of students to apply concepts to the source of the problem to solve the target problem is still not good. Based on the interview results, students also stated that to solve the target problem, they only referred to the information about the problem, which stated that the source of the problem and the target of the problem were similar. The student can understand the meaning of the problem as a whole but is not good enough to solve the problem in the allotted time.

Students with a concrete random thinking (CR) style have an average test score of 27.83, which is included in the moderate mathematical analogical reasoning category. In general, at the *encoding stage*, students' ability to write down information from the problem's source and the problem's target is quite good. At the *inferring stage*, the student's ability to perform calculations to determine a low relationship to the source of the problem or to conclude a low relationship from the calculation results is still not good. At the *mapping stage*, students' ability to identify the relationship between the source of the problem and the target problem is still lacking. At the *applying stage*, the participant's ability to use the concept of the source of the problem to solve the target problem is still not good. This also follows the results of interviews with students; in solving problems, they do not pay attention to the sequence of stages of problem-solving. Students with this CR thinking style sometimes get caught up in the process, so they forget to reach the final result or run out of time to complete assignments). Several CR students cannot complete the questions given in the allotted time.

Students with an abstract sequential thinking style (AS) have an average test score of 31.50, so they are included in the category of moderate mathematical analogical reasoning ability. In general, at the *encoding stage*, students' ability to write down information from the problem's source and the problem's target is good. At the *inferring stage*, students' ability to perform calculations to determine the relationship to the source of the problem is quite good. At the *mapping stage*, students' ability to identify similarities between the source of the problem and the target problem is quite good. At this stage of *application*, students' ability to use the concept of the source of the problem to solve the target problem is still not good. During the interview, the student stated that he used his imagination to determine the size of the blocks, based on a picture of the net pattern, by determining the length, width, and height of the blocks, which could vary depending on how one sees the position of the blocks. This shows that these students can analyze information using their imagination and are also able to convey their ideas. Still, they are not good at understanding the concepts used in problem-solving.

Students with concrete sequential thinking (CS) style have an average test score of 46.25, so they are included in the category of good mathematical analogical reasoning abilities. In general, at the *encoding stage*, students' ability to write information from the source of the problem to the target of the problem is very good. At the *inferring stage*, students' ability to perform calculations to determine low relationships at the source of the problem is very good. The student's ability to identify similarities between the source of the problem and the target problem is good at the mapping stage. At the *applying stage*, the student's ability to use the concept at the source of the problem to solve the target problem is good. This shows that students with the CS learning style capture information using the five (concrete) senses, process it sequentially based on reality, and process information linearly. Based on the results of the interviews, it appears that students can explain their answers regularly or gradually. This is because students with the CS thinking style pay attention and can remember reality using facts, information, formulas, and special rules easily. At this stage, students must perform calculations using the formula for the volume or surface area of cubes and blocks to solve source and target problems.

In general, the results of this study indicate that students with concrete sequential thinking styles have mathematical analogical reasoning abilities in the good category. In contrast, students with random abstract, concrete random, and abstract sequential thinking styles have mathematical analogical reasoning abilities in the moderate category. The same thing was also found in the research results of Firdaus et al. (2019), which showed that students with a concrete sequential thinking style had better critical thinking skills than other types of thinking styles. Research also conducted by Fitriana et al. (2019) shows that students with an abstract sequential thinking style have better mathematical reasoning than other types of thinking.

Based on the results of the study, it can be seen that each student has a different style of thinking. Each type of thinking style has a unique character. These characters can influence a person's actions in achieving his goals, including learning. For this reason, students need to know the type of thinking style they have to maximize their abilities. For a teacher, knowing students' thinking styles is also important so that teachers can choose appropriate learning methods to optimize students' abilities.

CONCLUSION

Based on the study's results, the most dominant thinking style in students' mathematical analogical reasoning abilities was concrete sequential in the good category, with an average value of 46.25. Students with a concrete sequential thinking style capture information and process it sequentially, resulting in good problem-solving outcomes. The random sequential thinking style in the medium category obtained an average score of 31.50, indicating that the student could analyze information and convey ideas but was not good at understanding the concepts used in the questions. Students with a random concrete style get an average score of 27.83, while students with a random abstract style get an average of 32.07 in the medium category, which shows that students with this thinking style can understand the meaning of the problem as a whole but are not good enough at solving problems within the specified time. These results can be used as a reference for teachers to continue improving students' mathematical analogical reasoning abilities by maximizing students' potential according to the character of their thinking style.

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AUTHOR CONTRIBUTION STATEMENT

VF: Designing, conceptualizing, analyzing, and editing.
EY: Designing research instruments, drafting the manuscript, correcting, and final approval.
DS: Editing, reviewing, proofreading, and providing technical support.

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